Arduino : Magic Wand, Binary Number Predictor

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13 Avril 2024

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2 Introduction

In the era of Tiny Machine Learning (TinyML), the integration of machine learning algorithms with microcontrollers opens up a realm of possibilities for intelligent edge computing. In this context, Arduino Nano 33 BLE Sense board emerges as a powerful platform, equipped with an on-board Inertial Measurement Unit (IMU) and a capable Arm Cortex-M4 processor. Leveraging these features, developers can implement gesture recognition directly on the Arduino board itself, without the need for external processing.

The provided Arduino sketch exemplifies this integration, demonstrating how TensorFlow Lite (Micro) can be utilized for gesture classification. By capturing motion data from the IMU, preprocessing it, and feeding it into a pre-trained machine learning model, the Arduino board is empowered to recognize specific gestures in real-time. This advancement not only showcases the potential of TinyML but also underscores the democratization of machine learning, making it accessible to a broader audience of developers and hobbyists.

3 Data Collection

For data collection, the project utilized an Arduino Nano 33 BLE Sense board equipped with sensors for capturing motion data. A custom sketch was developed to monitor the board's accelerometer and gyroscope, triggering a sample window upon detecting significant linear acceleration. This sketch sampled data for one second at 119Hz, outputting it in CSV format over USB. The process involved reading acceleration and gyroscope data, summing up the absolutes, and checking if the values exceeded a predefined threshold. ArduSpreadSheetr, an automated tool, facilitated the automatic export of data to CSV format, ensuring efficient data collection directly from the Arduino board without the need for manual intervention, and making labeling data more easy.

4 Machine Learning

The project progresses to machine learning (ML) implementation, aiming to classify accelerometer and gyroscope data using a TensorFlow model on the Arduino Nano 33 BLE Sense. Initially, the notebook sets up the Python environment, installing necessary dependencies such as Pandas, NumPy, and TensorFlow. Data collection involves parsing CSV files containing gesture data, preparing them for training a fully connected neural network. The dataset is randomized and split into training, validation, and testing sets. A TensorFlow model is then built and trained using the Keras API, with performance metrics visualized to assess model convergence. Subsequently, the trained model is applied to test data, and predictions are plotted against actual values. Finally, the model is converted to TensorFlow Lite format and encoded into a byte array for deployment on the Arduino platform. This transition marks a crucial phase, shifting from data collection and preparation to ML model development and deployment, leveraging the capabilities of TensorFlow for gesture recognition on resource-constrained devices like the Arduino Nano 33 BLE Sense.

5 Arduino

The collected sensor data is then normalized and stored in the input tensor of the TensorFlow Lite model. Once enough samples are collected, the model is invoked to perform inference. The output tensor contains the probabilities of each gesture class, which are then printed to the serial monitor. The setup includes initializing the IMU, loading the TensorFlow Lite model from a header file (model.h), and configuring the TensorFlow Lite interpreter. The sketch continuously loops, waiting for significant motion and collecting sensor data until enough samples are obtained for classification. This implementation enables real-time

gesture recognition directly on the Arduino board, showcasing the potential of TinyML for edge computing applications. By leveraging machine learning models on microcontrollers, developers can create intelligent and interactive IoT devices with embedded intelligence.

6 Conclusion

In conclusion, the fusion of Arduino boards with TensorFlow Lite represents a significant stride towards embedding intelligence into everyday devices. By harnessing the computational capabilities of microcontrollers and the efficiency of machine learning models, developers can create interactive and responsive IoT applications. The example of gesture recognition on Arduino Nano 33 BLE Sense board illustrates the practicality and versatility of TinyML, paving the way for a new generation of intelligent devices that can perceive and respond to their surroundings in real-time. As TinyML continues to evolve, it promises to revolutionize various domains, from smart wearables to home automation, driving innovation and empowering creativity in the IoT ecosystem.